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Anomalous large amplitude geomagnetic sudden commencement (SC)

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The CRRES satellite detected instantaneous formation of the inner radiation belt near the equator in L=2.6Re and 2.5h local time at 0341 UT, March 24, 1991 [Blake et al., 1992]. At this time ground geomagnetic observatories globally observed an SC preceded by a large amplitude pulse of short duration [Araki et al., 1997]. The H-component amplitude and duration of the pulse was measured as 202 nT and 1 min, respectively by 1 sec values at Kakioka observatory. The 1 min values of routine geomagnetic observations can not record such a rapid variation accurately. Since the SC amplitude at Kakioka is usually less than 50 nT and the rise time is mostly 3-4 min, the amplitude of this pulse is anomalously large and the duration is anomalously short. A computer simulation by Liu et al. [1993] shows that an electromagnetic pulse due to the magnetospheric compression accelerated magnetospheric partcles to form the inner radiation belt. The data of EXOS-D (Akebono) satellite indicates that this radiation belt lasted more than one year [Yukimatsu et al, 1996]. Although it is interesting to see the corresponding solar wind variations, there is no data of the solar wind.

Being stimulated by this SC, we checked the SSC list publicized by Kakioka observatory since 1924.
It shows that the 1991 SC mentioned above is the second largest. The largest SC occurred on March 24, 1940. Referring to the SC list by Mayaud [1973] this seems to be the largest since 1868. If we include SI (Sudden Impulse) for which Kakioka observatory publicizes the list separately, the 1991 SC is the third largest. The second largest is an SI (220nT) occurred on November 13, 1960.

The currents induced in the earth depend upon the time variation rate of the SC. It is known that the SC amplitude correlates positively with its time variation rate [Araki et al., 2004] and so larger SCs induce stronger induction currents. Usually a linear relationship is assumed between the SC amplitude dH and jump in the square root of Pd, d(Pd∗∗0.5) as dH=A∗d(Pd∗∗0.5) and A is experimentally estimated as about 15 nT/[Pd(nPa)]∗∗0.5. If this A is used for SC with 200nT amplitude, Pd should be increased from 2nPa (quiet time value) to 210 nPa , but the non-linear effect will require a larger Pd.

In the estimation of A the induction effect is usually assumed to be 1.5 (i.e. SC is amplified 1.5 times on the earth). For more accurate considerations of SC, however, the induction effect should be estimated taking the time variation rate of each SC into account.

Prof. Rikitake said ; Although researchers of the upper atmosphere use observed amplitude of SCs, it is important to consider the effects of induction currents.

Keywords: geomagnetic sudden commencement(SC), historically largest SC, radiation belt, particle acceleration, induced earth current